Bridge measurement of R, L, C

LEVEL-2:

01. Ans: (c)

Hint: Instrument sensitivity = $\frac{\text{Change in deflection}}{\text{Change in resistance}}$

$$= \frac{3}{6}\ \text{mm}/\Omega$$

$$= 0.5\ \text{mm/ohm}$$

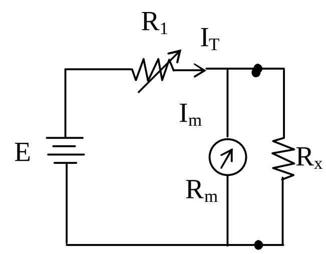
02. Ans: (d)

Hint: With R_x disconnected, the full scale current

$$I_m = \frac{E}{R_1 + R_m}$$

Given that the new current $I_{New} = SI_m \rightarrow (1)$

The New current can be obtained as



$$I_T = \frac{E}{R_1 + \frac{R_m R_x}{R_m + R_x}}$$

From current division rule,

$$I_{New} = \frac{E}{R_1 + \frac{R_m R_x}{R_m + R_x}}\left[\frac{R_x}{R_m + R_x}\right]$$

$$= \frac{ER_x}{R_1(R_m + R_x) + R_m R_x}$$

From (1)

$$\frac{ER_x}{R_1(R_m + R_x) + R_m R_x} = \frac{R_x}{R_x + R_p}\left[\frac{E}{R_1 + R_m}\right]$$

$$R_x(R_1+R_m) + R_p(R_1+R_m) = R_1R_m+R_1R_x+R_mR_x$$

$$R_p = \frac{R_1 R_m}{R_1 + R_m}$$

03. Ans: (d)

Hint: Given data $Z_1 = 450\ \Omega$

$$Z_2 = (300 - j600)\Omega$$

$$Z_3 = (200 + j\,100)\Omega$$

Under balance $Z_1Z_3 = Z_2Z_4$

$$450\,(200 + j100) = (300 - j600)Z_4$$

$$\frac{450 \times (200 + j100)(300 + j600)}{(300)^2 + (600)^2} = Z_4$$

$$\frac{450 \times 10^4 (2 + j)(3 + 6j)}{450 \times 10^3} = Z_4$$

$$10[6 + 15j - 6] = Z_4$$

$$\therefore\ Z_4 = (0 + j150)\,\Omega$$

04. Ans: (d)

Hint: The given bridge is wein's bridge.

under balance

$$R_4\left[R_1 \frac{1}{j\omega C_1}\right] = R_2\left[\frac{R_3}{j\omega C_3 R_3 + 1}\right]$$

$$R_1R_4(j\omega C_3R_3 + 1) + \frac{R_4}{j\omega C_1}\left[j\omega C_3R_3 + 1\right] = R_2R_3$$

Compare real and imaginary terms

$$\omega R_1R_4C_3R_3 - \frac{R_4}{\omega C_1} = 0$$

$$\omega = \frac{1}{\sqrt{C_1C_3R_1R_3}}$$

If $R_1 = R_3 = R$ and $C_1 = C_3 = C$

$$\omega = \frac{1}{RC}$$

And real part,

$$R_1R_4 + \frac{R_4C_3R_3}{C_1} = R_2R_3$$

$$\Rightarrow R_4\left[R_1 + \frac{C_3R_3}{C_1}\right] = R_2R_3$$

If $R_1 = R_3$ and $C_1 = C_3$

$$R_4[R_3 + R_3] = R_2R_3$$

$$\Rightarrow R_2 = 2R_4$$

05. Ans: (a)

Hint: under balanced condition,

$$Z_x\left[\frac{4000}{j\omega 0.05\mu\times 4000+1}\right] = 2000\times 750$$

$$Z_x = \frac{750}{2}(1+j\omega\times 10^{-3})$$

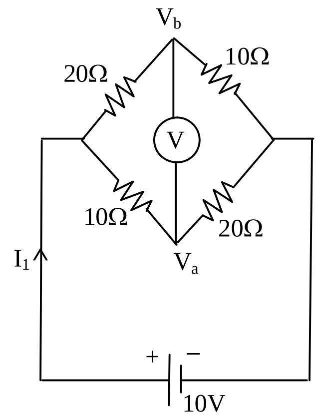
$$R_x + j\omega L_x = 375 + j75\times 10^{-3}\omega$$

Compare real and imaginary terms

$R_x = 375\Omega$ and $L_x = 75\text{mH}$

06. Ans: (d)

Hint: The given bridge is unbalanced bridge



$$V_b = 10\times\frac{10}{30} = 3.33\text{ V}$$

$$V_a = 20\times\frac{10}{30} = 6.66\text{ V}$$

Voltmeter reading = $V_a - V_b$

= 6.66 – 3.33

= 3.33 V

10. Ans: (b)

Given $\frac{X_C}{R} = 1$

Volt meter reading = $V_{ab} = V_a - V_b$

$$V_a = \frac{10\times R}{R+R} = 5\text{V}$$

$$V_b = \frac{10\times X_C}{X_C+R} = \frac{10}{1+\frac{R}{X_C}} = \frac{10}{2} = 5V$$

$\therefore$ Voltmeter reading $V_{ab} = 0\text{V}$

11. Ans: (a)

Sol: $V_{ab} = V_a - V_b = \frac{30\times 10}{30} - \frac{30\times 2}{10} = 4$

Energy stored in capacitor = $\frac{1}{2}CV_{ab}^2 = \frac{1}{2}\times 1\times 10^{-6}\times 4^2 = 8\mu\text{J}$

12. Ans: (d)

Sol : Take $I = I_1 + I_2$

I_1 = inner loop current and I_2 = outer loop current

from KVL.

$-V_S + 2 + 2 \times 10^3 I_2 = 0 \rightarrow (1)$

and $-V_S + 5 \times 10^3 I_1 = 0 \rightarrow (2)$

Given $V_0 = 0$, therefore voltage across 4KΩ is equal to voltage across 2 KΩ.

$4 \times 10^3 I_1 = 2 \times 10^3 I_2$

$I_2 = 2I_1 \rightarrow (3)$

By solving (1), (2) and (3)

$I_1 = 2mA, I_2 = 4mA$

$\therefore I = 6mA$

13. Ans: (a)

Sol :

Given $V_1 = \sqrt{2}\cos 1000t$ V

$V_2 = 2\cos(1000+45^o)$ and $V_d = 0$

V_1 is the voltage across the resistor R = 100Ω, since $V_d = 0$

$$\therefore I_2 = \frac{V_1}{R} = \frac{\sqrt{2}\cos 1000t}{100}$$

V_2 is the voltage across the impedance Zx.

$$V_2 = 2\,\text{Cos}(1000t + 45^o)$$

$$I_2 = \sqrt{2} \times 10^{-2}\cos 1000t$$

Here V_2 leads the current I_2 with the phase angle 45°.

Hence the element is inductor with some resistance.

$$\text{Now } R = \frac{V_2}{I_2}\cos 45^o$$

$$= \frac{2}{\sqrt{2}\times 10^{-2}} \times \frac{1}{\sqrt{2}} = 100\ \Omega$$

$$\text{and } X_L = \frac{V_2}{I_2}\sin 45^o = \frac{2}{\sqrt{2}\times 10^{-2}} \times \frac{1}{\sqrt{2}}$$

$X_L = 100\Omega$ and $L = \dfrac{100}{1000} = 100$ mH

14. Ans: (c)

Sol :

$$\text{The voltage across } R_2 \text{ is} = \frac{ER_2}{R_1 + R_2} = \frac{E}{2}$$

Therefore voltage across R_1 is also $\dfrac{E}{2}$.

$$\text{Now } \frac{E}{2} = IR_3 + V$$
$$\therefore I = \frac{E - 2V}{2R}$$

$$\text{and } \frac{E}{2} = IR_4$$
$$\frac{E}{2} = \left(\frac{E - 2V}{2R}\right)(R + \Delta R)$$
$$R + \Delta R = \frac{ER}{E - 2V}$$
$$\therefore \Delta R = \frac{2VR}{E - 2V}$$

15. Ans: (b)
Sol :
Under balanced condition
$(X_C \| 10K\Omega)Z = 500 \times 1K\Omega$
$$\frac{10^4 Z}{1 + j\omega 100 \times 10^{-9} \times 10^4} = 5 \times 10^5$$

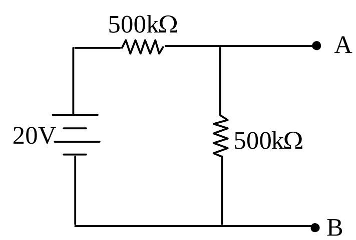
$$Z = 50[1 + j\omega 50 \times 10^{-3}]$$

$$= 50 + j\omega\, 50 \times 10^{-3}$$

16.
Ans: (d)
Sol: Voltage across the 500kΩ resistor is exactly 10V
Sensitivity of voltmeter 20kΩ/V
The readings indicated on its 50V and 5V range?

Voltage across V_{AB} by voltage division rule

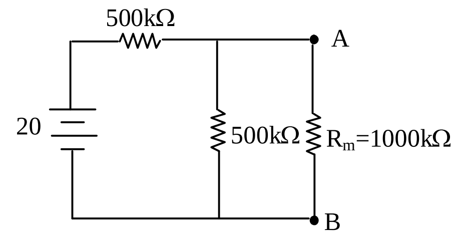
$$V_{AB} = \frac{500}{500 + 500} \times 20$$
V_{AB} = 10V



Reading indicated on 50V range is
R_m = S × voltage range
$R_m = 20 \times 10^3 \times 50 = 1000$ kΩ

R_m connected across 'AB'
$$R_{eq} = \frac{500 \times 1000}{500 + 1000} = 333.3\Omega$$

$$V = 20 \times \frac{333.3}{500+333.3} = 8V$$



Reading indicated on '5V' range is

R_m = S × voltage range

$R_m = 20 \times 10^3 \times 5 = 100k\Omega$

$$R_{eq} = \frac{500\times100}{500+100} = 83.33\Omega$$

$$V = 20 \times \frac{83.33}{500+83.33} = 2.86V$$

17. Ans (a)

Sol: 41 = E / (0.5MΩ +10KΩ) and

51 = E / (R_m +10KΩ)

Take ratio then R_m value is 0.4MΩ

18.

Ans: (a)

Sol: Each arm having a guaranteed accuracy error of ±0.5%

Standard arm has a guaranteed accuracy of ±1%

Ratio arms of are both set at 1000Ω

Bridge is balanced with standard arm adjusted to determine the upper and lower limits of unknown resistance?

Value of unknown resistance $R = \left(\frac{P}{Q}\right)\times S$

$$= \frac{1000}{1000}\times 3154$$

$= 3154\Omega$

% error in determination of R

$$R = \frac{1000(\pm 0.5\%)}{1000(\pm 0.5\%)}\times 3154(\pm 1\%)$$

R = 3154±[0.5%+0.5%+1%]

= 3154± 2%

The upper and lower limits of unknown resistance is 3091 to 3217Ω

19.

Ans: (a)

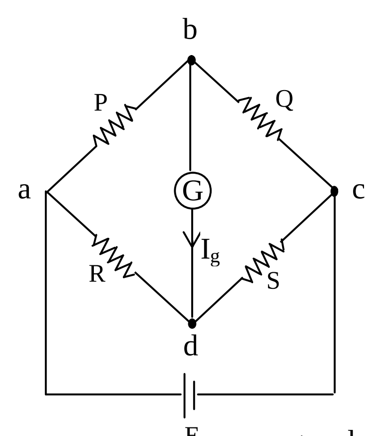
Sol: Given that

P = 1kΩ, R = 1kΩ

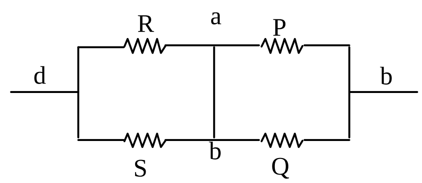
S = 5kΩ G = 100Ω

Thevenine voltage E_0 = 24mV

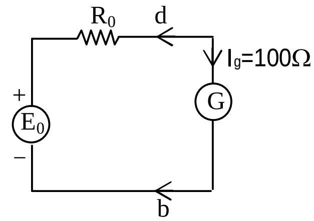
$I_g = 13.6\mu A$



From circuit find thevenin equivalent circuit.



$$R_0 = \frac{RS}{R+S} + \frac{PQ}{P+Q}$$



$$I_0 = \frac{E_0}{R_0 + G}$$

$$R_0 + G = \frac{24\times10^{-3}}{13.6\times10^{-6}} = 1764.70$$

$$R_0 = 1764.7 - 100 = 1665\Omega$$

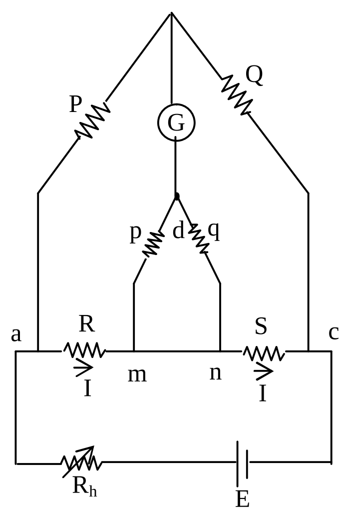
$$R_0 = \frac{1000\times5000}{1000+5000} + \frac{1000\times Q}{1000+Q}$$

$$\frac{1000Q}{1000+Q} = 8317$$

$$Q = 4.95k\Omega$$

20.

Ans: (a)



Sol: $S = 100.03 \times 10^{6}\Omega$

$p = 100.31\Omega$ $P = 100.24$

$q = 200\Omega$ $Q = 200\Omega$

$r = 100\times 10^{-6}\Omega$

$$R = \frac{P}{Q}.S + \frac{qr}{p+q+r}\left[\frac{P}{Q} - \frac{p}{q}\right]$$

$$R = \frac{100.24}{200}\times100.03\times10^{-6} + \frac{200\times100\times10^{-6}}{100.31+200+100\times10^{-6}}\left[\frac{100.24}{200} - \frac{100.31}{200}\right]$$

$R = 49.97\times10^{-6}\Omega$

21.

Ans: Given that

Sol: $C = 600pF$

$V = 250V$ $\nu = 92V$

Insulation resistance $R = \dfrac{0.43 \times t}{C \log_{10}\left(\dfrac{V}{\nu}\right)}$

$$R = \frac{0.434 \times 60}{600 \times 10^{-12} \times \log_{10}\left(\dfrac{250}{92}\right)}$$

$R = 9.99 \times 10^{10}$

$R = 100 \times 10^{9}\ \Omega$